Claims

[c1] A method for forming a buried plate in a trench capacitor, the method comprising the steps of:

forming at least one trench with a sidewall in a semiconductor substrate;

partially filling the trench with a dopant source material to form a dopant source having a top surface below a top of the trench, the dopant source material containing at least one dopant;

forming a dielectric collar on the sidewall of the trench above the dopant source;

heating the substrate to cause the dopant to diffuse into the substrate in the trench not covered by the dielectric collar, thereby forming the buried plate; and

removing the dopant source material from the trench.

[c2] The method of Claim 1, wherein the semiconductor substrate is formed of silicon.

[c3] The method of Claim 1, wherein the trench is partially filled by a method comprising the steps of:

filling the trench with a dopant source material to form a dopant source having a top surface at or above the top of the trench; and

recessing the top surface of the dopant source below the top

of the trench.

[c4] The method of Claim 1, wherein the dopant source material is arsenic-doped glass.

[c5] The method of Claim 1, wherein the dielectric collar is formed of nitride.

[c6] The method of Claim 5, wherein the dielectric collar is formed by low pressure chemical vapor deposition.

[c7] The method of Claim 5, further comprising the step of forming a thin layer of oxide on the sidewall of the trench prior to forming the dielectric collar.

[c8] The method of Claim 1, wherein the substrate is heated to a temperature of about 800 C to about 1200 C, for a time of about 1 to about 60 minutes.

[c9] The method of Claim 8, wherein the substrate is heated to a temperature of about 1050 C.

[c10] The method of Claim 1, wherein the substrate is heated in an oxygen-containing atmosphere.

[c11] The method of Claim 10, wherein during the heating step, a layer of oxide is grown between the dopant source material and the substrate.

[c12] The method of Claim 11, further comprising the step of

removing the layer of oxide, thereby forming a bottle-shaped trench.

[c13] The method of Claim 1, further comprising the step of depositing a plurality of hemispherical grains in the trench after the dopant source material is removed.

[c14] The method of Claim 1, further comprising the step of removing the dielectric collar.

[c15] The method of Claim 1, further comprising the step of etching the substrate in the lower portion for form a bottle shape trench after the dopant source material is removed.

[c16] The method of Claim 15, wherein the substrate is etched using ammonia.

[c17] A method for forming a buried plate in a trench capacitor, the method comprising the steps of:

forming at least one trench with a sidewall in a semiconductor substrate;

partially filling the trench with a dopant source material to form a dopant source having a top surface below a top of the trench, the dopant source material containing at least one dopant;

depositing a second material on the dopant source, thereby filling the remainder of the trench and covering the sidewall of the trench above the dopant source;

heating the substrate to cause the dopant to diffuse into the substrate in the trench not covered by the second material, thereby forming the buried plate; and

removing the second material and the dopant source material from the trench.

[c18] The method of Claim 17, wherein the semiconductor substrate is formed of silicon.

[c19] The method of Claim 17, wherein the trench is partially filled by a method comprising the steps of:

filling the trench with a dopant source material to form a dopant source having a top surface at or above the top of the trench; and

recessing the top surface of the dopant source below the top of the trench.

[c20] The method of Claim 17, wherein the dopant source material is arsenic-doped glass.

[c21] The method of Claim 17, wherein the second material is un-doped oxide.

[c22] The method of Claim 21, wherein the second material is deposited by low pressure chemical vapor deposition or high density plasma chemical vapor deposition.

[c23] The method of Claim 17, wherein the substrate is heated to a

temperature of about 800 C to about 1200 C, for a time of about 1 to about 60 minutes.

[c24] The method of Claim 23, wherein the substrate is heated to a temperature of about 1050 C.

[c25] The method of Claim 17, wherein the substrate is heated in an oxygen-containing atmosphere.

[c26] The method of Claim 23, wherein during the heating step, a layer of oxide is formed between the dopant source material and the substrate.

[c27] The method of Claim 1, further comprising the step of exposing the substrate to at least one of gas phase doping, plasma doping and plasma immersion ion implantation.

[c28] The method of Claim 13, further comprising the step of exposing the substrate to at least one of gas phase doping, plasma doping and plasma immersion ion implantation, after depositing a plurality of hemispherical grains.